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DISTRIBUTION OF BIOMASS AND PRODUCTION FOR SEVERAL NORTHERN WOODY SPECIES

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ABSTRACT.— Relative distributions of biomass and net primary production among plant components are reported for three tree species and four shrub species common to the northern deciduous forest.

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Biomass and production relations for several woody species common to the northern forest were determined as part of a study conducted in the Enterprise Forest near Rhinelander, Wisconsin (Rudolph 1974, Zavitkovski 1977). Four shrubs, *Vaccinium myrtilloides, Rubus allegheniensis, Corylus cornuta, Ilex verticillata,* and three trees, *Acer rubrum, Acer saccharum, Betula papyrifera,* were sampled. These species represent a spectrum of growth forms and plant sizes. The relative distributions of biomass and production by plant component, with comparisons among species, are reported here.

The procedures for selection of samples and the determination of biomass and net primary production have been reported (Crow 1978). The figures presented in tables 1 and 2 were determined from dry weight values.

The obvious differences in proportionalities of biomass and production between *Rubus* and other shrub species can be attributed to its growth form (table 1). From an underground, perennial base, several aerial, biennial stems are produced; these stems were harvested in this study. During the first growing season, the biennial stems (primocanes) are usually unbranched and rarely produce inflorescence; during the second growing season, these stems (floricanes) cease growth but produce a number of short lateral branches, often with terminal inflorescence. Leaves and current twigs accounted for all the biomass of primocanes. Biomass distribution for the floricanes was divided among the first-year stem (36 percent stem and branches), the lateral branches (63 percent leaves and current twigs), and fruit (1 percent).

Among the other shrub species, stem and branch biomass ranged from 64 to 89 percent and current twig and leaf weight ranged from 35 to 11 percent

Table 1.—*A summary of mean dimensional and functional relations for shrub species sampled in the Enterprise Forest*

Item	*Vaccinium myrtilloides*	*Rubus allegheniensis*		*Corylus cornuta*	*Ilex verticillata*
		primocanes	floricanes		
Sample number	69	62	41	70	20
Basal diameter (mm)					
Mean	4.0	4.6	4.9	11.8	14.9
Range	2.3-6.3	2.4-8.2	3.1-7.9	4.0-24.4	8.6-24.9
Stem length (cm)					
Mean	46.4	71.6	56.7	175.1	196.2
Range	30-90	30-137	30-105	42-355	110-290
Biomass distribution (percent of total aboveground dry weight)					
Stem and branches	64.5	0	36.3	75.9	89.2
Leaves and current twigs	35.1	100	62.5	23.6	10.7
Fruit	<1.0	0	1.2	<1.0	<1.0
Net production distribution (percent of total aboveground dry weight)					
Stem and branches	13.8	0	0	11.1	17.6
Leaves and current twigs	84.3	100	99.2	86.4	81.9
Fruit	1.9	0	<1.0	2.5	<1.0

Table 2.—*A summary of mean dimensional and functional relations for tree species sampled in the Enterprise Forest*

Item	*Acer rubrum*	*Acer saccharum*	*Betula papyrifera*
Sample number	23	25	21
D.b.h. (cm)			
Mean	10.4	10.4	13.7
Range	3.1-24.6	3.5-26.0	3.5-26.3
Total height (m)			
Mean	11.54	11.53	14.04
Range	5.29-18.50	5.50-19.31	5.68-21.18
Biomass distribution (percent of total aboveground dry weight)			
Bolewood	63.8	64.6	68.8
Bolebark	10.3	8.3	12.3
Branches	20.5	22.2	15.8
Leaves and current twigs	5.4	4.9	3.1
Net production distribution (percent of total aboveground dry weight)			
Bolewood	29.7	29.8	36.9
Bolebark	5.5	6.9	8.8
Branches	22.7	18.8	19.9
Leaves and current twigs	42.1	44.5	34.4

for the small shrub *Vaccinium* to the large shrub *Ilex*, respectively. For all species, the fraction of dry weight represented by fruit and fruiting bodies was 1 percent or less of the aboveground biomass.

Despite structural differences, the distribution of production among various components was very similar for *Vaccinium, Corylus,* and *Ilex* (table 1). Radial growth on stems accounted for only 11 to 18 percent of the aboveground shrub production. The proportions of growth in current twigs and leaves ranged from 82 to 86 percent of aboveground production.

Among the trees sampled, bolewood accounted for 64 to 69 percent of the aboveground biomass, bolebark 8 to 11 percent, branches 16 to 22 percent, and leaves and current twigs 3 to 5 percent (table 2). The distribution of biomass for the two maples corresponded closely for all components. Birch had more biomass in the stem and less in the canopy than did maple.

Distributional differences among species can be explained in part by morphological differences. For example, birch has many short-shoot twigs, each with a cluster of leaves. Minimal apical growth by these twigs results in less biomass classified as current twigs. The branching habit of birch—few large branches, many short, pendulous branches—could account for the lesser proportions of branch biomass in birch than in the maples.

Size is an important determinant in biomass distribution among components. There was a marked decrease in the proportion of bolebark with increasing stem size, a trend associated with the decrease in the surface-area/stem-volume ratio. Also present was a trend of increasing concentrations of woody tissue with increasing size of a plant. Except for *Rubus*, the percentage of woody biomass and net production increased from the smallest species to the largest species (tables 1 and 2). Net production in stem and branches together ranged from 55 to 66 percent for the trees and from 11 to 18 percent for shrubs (excluding *Rubus*).

The proportions of belowground and aboveground biomass also varied with plant size. The mean belowground/aboveground ratio for aspen, obtained from the excavation of 20 trees between 2 and 8 cm d.b.h., was 0.24±0.02 (±SE). For *Corylus*, a shrub of intermediate size, the mean ratio

was 1.03±0.07 (N=49) and for *Vaccinium*, a small shrub, the mean ratio was 1.96±0.32 (N=7). Other reports of belowground/aboveground biomass ratios for trees ranged from 0.2 to 0.3 for young trees to less than 0.2 for large trees (Ovington 1962), and ratios for shrubs range from 0.6 to 1.8 (Whittaker 1962). The average belowground/aboveground ratio for herbaceous species harvested at Enterprise ranged from 2.98 to 4.79 (Zavitkovski 1976). Thus, 19 percent of the total dry weight for the tree was belowground, compared to 51 percent for the intermediate shrub, 66 percent for the small shrub, and 75 to 83 percent for the herbaceous species.

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